

CRYSTALLINE SILICA

CAS Registry Numbers: 7631-86-9
Quartz: 14808-60-7
Tridymite: 15468-32-3
Cristobalite: 14464-46-1

SiO₂

Molecular Formula: SiO₂

Silica exists in crystalline, amorphous, and/or glassy states. The three major forms of crystalline silica are the polymorphs, quartz, cristobalite, and tridymite. These crystalline polymorphs are identical chemically and can change form under different conditions of temperature and pressure. The basic structural unit of crystalline silica minerals is the silicon tetrahedron, SiO₄. Each of the four corners of the tetrahedron links with another tetrahedron to form a three-dimensional framework (Deer et al., 1966). Slight variations in the orientation of the silicon tetrahedra with respect to each other result in the development of new symmetry, producing the different crystalline silica polymorphs. A completely random orientation of these units results in the amorphous/glassy varieties of the material (IARC, 1987c). Crystalline silica is essentially insoluble in water, alkalies, or acids (except hydrofluoric acid in which it readily dissolves). It combines chemically with most metallic oxides (Merck, 1989).

Physical Properties of Crystalline Silica

Synonyms: Silicon dioxide; quartz; silica; silica anhydride; cristobalite; glass; tridymite; silica flour; sand; agate; flint; stishovite; tripoli; cherts; chalcedony; coesite; jasper; amethyst

The molecular weight for all forms is 60.08 and the boiling point is 2,230 °C.

Polymorphic Forms

	<u>Quartz</u>	<u>Tridymite</u>	<u>Cristobalite</u>
Melting Point:	1610 °C	1703 °C	1723 °C
Density/Specific Gravity:	2.65 (water = 1)	2.26 (water = 1)	2.32 (water = 1)
Crystalline Form	Hexagonal	Pseudohexagonal	Octahedral
Color:	Colorless White Purple Black Green	Colorless White	Colorless White Yellowish

(IARC, 1987c; Sax, 1989; Weast, 1989)

SOURCES AND EMISSIONS

A. Sources

Stationary sources of crystalline silica are aggregate (rock, sand, and gravel) operations; ore mining and tunneling operations; coal mining; granite and stone quarrying and processing operations; ceramics, glass, brick, clay pipe/tile, and cement manufacturing; foundries and metallurgical industries; sandblasting operations; demolition and construction; farming; pharmaceuticals and paint blending (ENSR, 1991; IARC, 1987c). Wind entrainment of particulates disturbed by plowing, bulldozing and/or grazing, or dirt roadway travel, as well as natural wind erosion, contribute to ambient levels of crystalline silica.

The primary stationary sources that have reported emissions of crystalline silica in California are sand and gravel mining, national security, and manufacture of pressed or blown glassware, based on data reported under the Air Toxics “Hot Spots” Program (AB 2588) (ARB, 1997b).

B. Emissions

The total emissions of crystalline silica from stationary sources in California are estimated to be at least 3.7 million pounds per year, based on data reported under the Air Toxics “Hot Spots” Program (AB 2588) (ARB, 1997b).

C. Natural Occurrence

Quartz, commonly seen as sand, constitutes about 12 percent of the earth's land mass and is a major component of soil. Sedimentary rocks such as sandstone, shale, and limestone predominate on land masses and contain great quantities of crystalline silica. Quartz is by far the most predominant form of crystalline silica, occurring as sand, sandstone, and in igneous rock (CMA et al., 1994).

AMBIENT CONCENTRATIONS

No Air Resources Board data exist for ambient measurements of crystalline silica.

INDOOR SOURCES AND CONCENTRATIONS

No information about the indoor sources and concentrations of crystalline silica was found in the readily-available literature.

ATMOSPHERIC PERSISTENCE

Crystalline silica will be in the particle phase in the atmosphere, and hence subject to wet and dry deposition. The average half-life and lifetime for particles in the atmosphere is estimated to be about 3.5 to 10 days and 5 to 15 days, respectively (Atkinson, 1995; Balkanski et al., 1993).

AB 2588 RISK ASSESSMENT INFORMATION

Although crystalline silica is reported as being emitted from stationary sources in California, no health values (cancer or non-cancer) are listed in the California Air Pollution Control Officers Association Air Toxics Hot Spots Program Revised 1992 Risk Assessment Guidelines for use in risk assessments (CAPCOA, 1993).

HEALTH EFFECTS

The most probable route of human exposure to crystalline silica is inhalation.

Non-Cancer: Prolonged inhalation of crystalline silica results in the development of silicosis, a chronic, fibrotic lung disease characterized by the formation of silica-containing scar nodules in the lung tissue (ACGIH, 1991; Amdur et al., 1991). The disease usually occurs in workplaces where the silica is being mechanically treated among individuals with inadequate respiratory protection. Although silicosis usually develops slowly, acute silicosis, a very rapidly progressing disease, can be induced by extremely high concentrations of very fine particles. Some reports have also indicated kidney toxicity after silica exposure (U.S. EPA, 1995a).

The United States Environmental Protection Agency (U.S. EPA) has suspended its development of a Reference Concentration (RfC) for crystalline silica (U.S. EPA, 1995a).

Cancer: Epidemiological evidence shows that workers who develop silicosis from occupational exposure are more likely to develop respiratory tract cancer (Goldsmith et al., 1986; Simonato et al., 1990). A multi-study analysis has indicated that the risk of death from lung cancer is approximately doubled among occupationally-exposed individuals relative to the general populations (Smith et al., 1995). However, it is not clear whether, in the absence of silicosis, silica exposure itself increases the risk of lung cancer.

The U.S. EPA has not classified crystalline silica with respect to its carcinogenic potential. The International Agency for Research on Cancer (IARC) has found that crystalline silica inhaled in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (Group 1). In making this overall evaluation, the IARC noted that the carcinogenicity in humans was not detected in all industrial circumstances and that carcinogenicity may be dependent on inherent characteristics of the crystalline silica or external factors. Amorphous silica is not classifiable as to its carcinogenic potential (Group 3) (IARC, 1996a). The State of California has determined under Proposition 65 that crystalline silica (airborne particles of respirable size) is a carcinogen (CCR, 1996).

